

Modal Mapping In A Complex Shallow Water Environment

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LONG-TERM GOALS

The long-term goal of this research is to increase our understanding of shallow water acoustic propagation and its relationship to the three-dimensionally varying geoacoustic properties of the seabed.

OBJECTIVES

The scientific objectives of this research are: (1) to develop high-resolution methods for characterizing the spatial and temporal behavior of the normal mode field in shallow water; (2) to use this characterization as input data to inversion techniques for inferring the acoustic properties of the shallow water waveguide; and (3) to use this characterization to improve our ability to localize and track sources.

APPROACH

An experimental technique is being developed for mapping the wavenumber spectrum of the normal mode field as a function of position in a complex, shallow water waveguide environment whose acoustic properties vary in three spatial dimensions. By describing the spatially varying spectral content of the modal field, the method provides a direct measure of the propagation characteristics of the waveguide. The resulting model maps can also be used as input data to inverse techniques for obtaining the acoustic properties of the waveguide. The experimental configuration consists of a fixed source radiating one or more pure tones to a field of freely drifting buoys, each containing a hydrophone, GPS navigation, and radio telemetry. In this context, two-dimensional modal maps in range *and* azimuth, as well as three-dimensional bottom inversion in range, depth, *and* azimuth, become achievable goals.

WORK COMPLETED

Our major accomplishment this year was the successful execution of the second Modal Mapping Experiment (MOMAX II), which was conducted aboard the R/V Gyre during the period 5-15 February 1999 in water depths ranging from 50 m to 150 m. A series of three experiments was carried out in the Gulf of Mexico, about 140 nmi west-northwest of Key West, FL, as part of the multi-institutional, multi-ship LWAD (Littoral Warfare Advanced Development) 99-1 Experiment. Four drifting MOMAX buoys, each containing a hydrophone, GPS navigation, and radio telemetry, received signals out to ranges of 10 km from a stationary source transmitting pure tones in the frequency range 50-250

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Hz. In addition to the acoustic measurements, extensive environmental data were also acquired, including 3-6 kHz chirp sonar subbottom data at each site, numerous CTD measurements throughout the region, and Seamon temperature logger data at several depths on each drifter buoy and on the source.

RESULTS

A preliminary examination of these measurements indicates that the data are of very high quality and offer great promise for achieving the goals of the research. Specifically, the following scientific achievements were accomplished in MOMAX II: (1) All three events were conducted with the source ship stationary (anchored or moored), thereby eliminating the ambiguity arising in the data when both source and receivers are moving. (2) We attained our longest continuous 2-D synthetic aperture, with a radial extent of about 5.1 km. (3) Preliminary processing suggests that we can process ship tonals successfully. The ability to process ship radiated noise has significant implications for future experiment design and for source tracking and localization. In addition, we continued our analysis of the extensive MOMAX I data set, concentrating on the application of high-resolution spectral estimation methods for tracking the modal peak trajectories and the development of new inversion techniques for inferring the geoacoustic properties of the seabed.

In a related effort, we made significant progress on the problem of extracting meaningful bottom reflection coefficient information from a deep-water data set obtained at 220 Hz in the Icelandic Basin in 1981. Several previous attempts at solving this problem had failed, but a new processing methodology developed in our group resulted in success. These reflection coefficient data will be input to exact inversion techniques that will enable the *unique* reconstruction of the geoacoustic properties of the seabed for the first time.

IMPACT/IMPLICATIONS

The experimental configuration consisting of a CW source and freely drifting buoys will provide a simple way to characterize a shallow water area and may be useful in survey operations. In addition, the planar, synthetic receiving array may offer an effective new technique for localizing and tracking CW sources in shallow water.

TRANSITIONS

The synthetic aperture technique and Hankel transform inversion methodology which underlies the modal mapping method has been implemented in the ACT II experiment, sponsored by DARPA and ONR. This approach has also been adopted by several research groups internationally.

RELATED PROJECTS

The LWAD 99-1 Project included a broad range of underwater acoustic and environmental measurements, in addition to MOMAX II. The results from these other experiments will be used to assist in the interpretation of the MOMAX II data.

We continued our collaborative effort with Professor Joyce McLaughlin's group in the Mathematical Sciences Department at the Rensselaer Polytechnic Institute. We are working together to apply exact, analytic inverse techniques developed, with partial ONR support, by her group to the problem of

inverting for the geoacoustic properties of the seabed using our shallow water acoustic measurements as input data.

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